ABSTRACT

New Capabilities and Mission Description for Performing the Galileo Mission Using the S-band Low Gain Antenna

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Following the failure of Galileo's X-band High Gain Antenna (HGA) to deploy in April 1991, an alternate approach which utilizes the spacecraft's S-band Low Gain Antenna (LGA) has been conceived and is in development. This approach will enable the accomplishment of at least 70% of Galileo's original scientific objectives.

Because of a concern over the long term reliability of the Command and Data Subsystem (CDS) memory devices for the 8.5 year VEEGA mission, the amount of CDS memory was doubled prior to the 1989 spacecraft launch. These devices have proven very reliable on both the Galileo mission and the Magellan mission, which flew an exact copy of the despun portion of the Galileo CDS. This "extended" memory, which is distributed equally in both of the redundant CDS strings, makes possible the proposed LGA based mission without impacting existing spacecraft redundancy (although the new capabilities will not be redundant).

Due to the limited amount of the CDS extended memory, implementation is divided into two phases. Phase 1 has the objective of providing an alternate path to Earth for the Jovian atmospheric Probe data. The original HGA based design relayed this data to Earth in real-time and simultaneously stored a copy on spacecraft's single tape recorder for later playback should the HGA link be interrupted during Probe Relay. The new Phase 1 design still stores a copy on the tape recorder and also takes advantage of the CDS extended memory to store a subset of the full Probe data set in that extended memory. This subset is sufficient to accomplish the primary science objectives of the Probe mission.

Several new flight and ground system capabilities must be added to enable the Phase 1 portion of the mission. The detail design, most of the coding, and part of the testing of these capabilities has been completed. Full flight and ground system testing will be accomplished during 1994 aiming towards an in-flight software load in March of 1995. Phase 1 software will remain active until after the return of the Probe symbol data in CDS extended memory three times and the return of the tape recorder data once. This will be accomplished by March 1996.

The second phase of the mission begins after the return of the Probe data. The goal of Phase 2 is to collect and return one tape recorder full (roughly 9 x 108 bits) of data at each often Jovian satellite encounters, return continuous fields and particles data throughout the nineteen months of Phase 2, and provide adequate visibility into the performance of the engineering portions of the spacecraft. These objectives require much more extensive changes to both the spacecraft software and to the ground system than for Phase 1,

Substantial reduction of the volume of data being returned to earth must be accomplished through editing (throwing away) of data, some use of lossy and lossless compression, and

a change from Time Division Multiplexed (TDM) telemetry to Packet Telemetry, all of which make more efficient use of the downlink channel.

Real time, pre-record, and playback editing or other data processing (such as time-averaging) is being provided for most of the eleven spacecraft instruments. Special software loads are being stored for some instruments in the CDS to allow them to change operating modes for collection of real-time or recorded data.

Lossy Integer Cosine Transform (lCT) data compression is being done in the Attitude and Articulation Control Subsystem (AACS) for Solid State Imaging (SS1) camera images and for lo-rate Plasma Wave Subsystem (PWS) data. Lossless compression of Near Infrared Mapping Spectrometer (NIMS) recorder playback data is being done in the CDS using the Rice algorithm.

Data from each source are assembled into appropriately sized packets. Packets will be assembled into eight kinds of Virtual Channel Data Units (VCDUs), stored in a multi-use buffer in the CDS extended memory, and packed into Frames for downlink as channel capacity permits. This same buffer is used to retrieve data from the spacecraft tape recorder before processing and to store processed recorder VCDUs.

To control downlink channel errors in the compressed data, additional software Reed-Solomon and convolutional coding is being added to augment the hardware convolutional coding already implemented on the spacecraft.

For additional channel gain, the spacecraft's Telemetry Modulation Unit (TMU) is being shifted from residual carrier to suppressed carrier modulation and the subcarrier modulation is being shifted to it's low rate (22.4 kHz) capability. This change takes advantage of the planned implementation of advanced digital receivers in the Deep Space Network (DSN) which are capable of receiving suppressed carrier signals.

Additional channel gain is also being added through the capability to array multiple DSN antennas. Arraying is being provided at the Canberra, Australia, complex to support the Canberra 70 meter antenna, three Canberra 34 meter antennas, and additional aperture such as the Parkes radio observatory. Additionally, during periods of coverage overlap, arraying between the Canberra complex and the Goldstone, California, complex will be available.

The S-band receive capability of the Canberra 70 meter antenna is also being augmented by the addition of an S-band low noise antenna cone, called an Ultracone, which lowers the effective noise temperature.

The DSN data network will also be shifted to a zero error, ensured delivery protocol, such as TCP/IP, to control errors in the data once it is on the ground.

Many changes to the Galileo specific ground system are also required to enable operation of the new spacecraft capabilities.